2.1 Interference Analysis Process

Figure 1 illustrates the general method to be employed in making a technically valid estimate of interference between an MSS subscriber unit and an aviation GLONASS receiver. The method takes into account the stochastic nature of the interference event - a key parameter when the interfering transmitter and victim receiver are in relative motion with respect to each other.

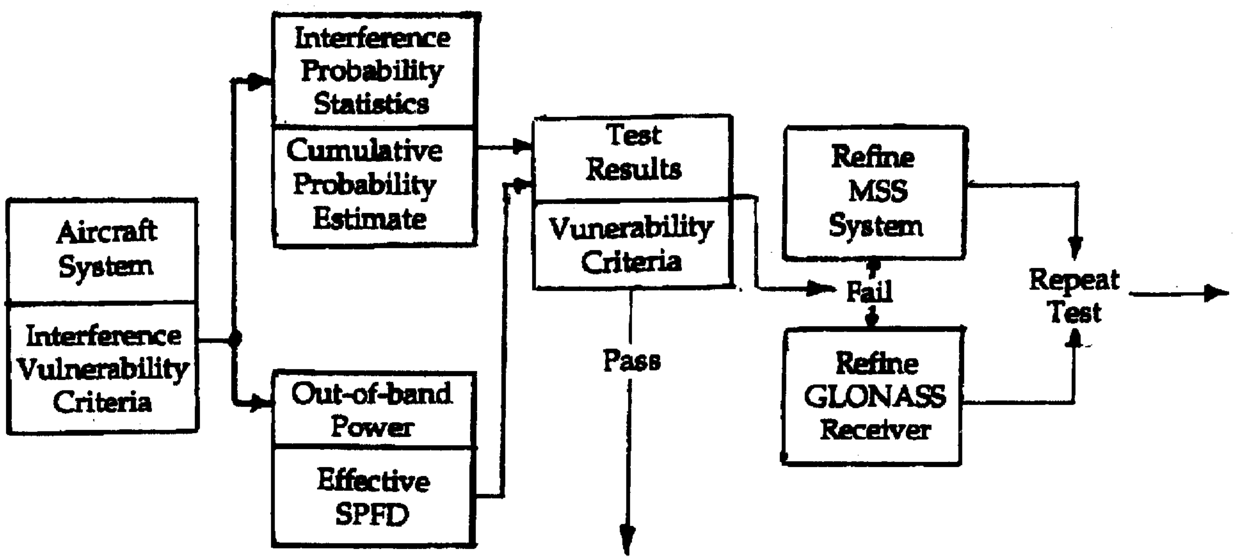

Figure 1 Interference Analysis Process Diagram

2.1.1 Aircraft System Considerations

The first step in the process is to establish a valid criteria for harmful interference. This criteria must include provisions for the manner in which GLONASS data are used by the particular aircraft navigation equipment. In all modern commercial passenger-transport aircraft, navigation data is a composite function, derived from a number of sensors such as the Inertial Navigation System (INS), the Global Positioning System (GPS), Differential GPS (DGPS), the Very high frequency Omni Range (VOR), the Instrument Landing System (ILS), radar and barometric altimeters, etc. GLONASS simply becomes an input to the composite, a contributor to overall system reliability as a redundant input signal.

An optimum selection of navigation sensor inputs is made by the aircraft flight data computer as a function of the phase of flight in process. Redundant operational modes are provided in the event of a failure or interruption of input sensor data. A simple example is the banking of an aircraft during turns. Airframe shadowing can temporarily interrupt or degrade the reception of radio and satellite signals. Navigation guidance is provided by the INS or autopilot system during turns; the flight data computer simply ignores radio and satellite sources that may be false during such maneuvers.

The failure or interruption of a single navigation sensor will not prevent an aircraft from accomplishing its intended maneuver. During landing phases the ILS, the DGPS, the INS or autopilot, and the pilot are available for aircraft guidance; quadruple redundancy exists. Even light aircraft incorporate redundant systems for navigation.

GLONASS is a member of the sensor team for redundancy purposes - not as a sole means of navigation. In fact there is doubt that GLONASS will be employed during landing maneuvers. No public data has yet been released by Russia on the development of a high accuracy Differential GLONASS system or the use of wide band GLONASS-M signals for precision guidance during landings.

Harmful interference criteria, for aviation navigation purposes, must be based on overall aircraft system requirements, not simply the characteristics of a single navigation sensor.

2.1.2 Propagation Path Considerations

The propagation path geometry and airframe shadowing between a subscriber transmitter and a GLONASS receiver on-board an aircraft must be taken into account. Two cases may be considered as follows:

a. An aircraft on a final approach path passing over an MSS transmitter. ARINC recommends a minimum distance of 100 meters be considered between the MSS transmitter and the GLONASS antenna..
b. An aircraft maneuvering to land wherein the GLONASS antenna is temporarily aligned (aircraft banking) to form a direct line-of-sight path with a subscriber transmitter. A minimum distance of 2000 meters is recommended between the two elements of the system.

An excellent analysis of item (a) is contained in Attachment 1 of the "Technical Appendix to Comments of Loral/Qualcomm Partnership, L. P., Volume I of II" (May 5, 1994). For the conditions stated therein (no airframe shadowing and a 75 mph approach speed) the analysis clearly shows that the time duration of exposure to an aircraft landing is less than 7 seconds. Given a realistic 15 to 30 dB allowance for airframe shadowing and a typical jet approach speed of 120 knots, the period of exposure is reduced to about 4 seconds and the interference power is reduced below the interference limit of the GLONASS receiver (see Table I).

Item (b) is a worst case of an aircraft turning on a base leg or a final approach leg. This scenario is also modeled in Table I.

Transient conditions must be viewed in terms of the TOTAL aircraft navigation system to determine whether or not harmful interference exists.

2.2 Example Worst Case CDMA Link Budget

The Radio Technical Commission for Aeronautics (RTCA) has provided specifications for the maximum amount of interference tolerable by GLONASS. Recent wording of these specifications suggest a 16 dB jamming margin allowance above the lowest GLONASS signal being tracked (-161 dBW) for in-band CW. The corresponding margin for in-band noise jamming is 21 dB above the lowest signal being tracked. From these data it can be assumed that a total jammer power of -145 dBW is tolerable for CW and -140 dBW for noise.

Table I considers a highly simplified worst case analysis of an MSS CDMA subscriber unit close to an aircraft on final approach and an aircraft banking. Table I shows that an MSS subscriber unit (of the CDMA type) will not interfere with GLONASS in either the 100 meter near-in case or the 2000 meter aircraft maneuvering case. If a second MSS subscriber unit were to located close to the first, both would have to transmit and have voice present at the same time to increase the interference - a highly unlikely event. This analysis assumes the following out-of-band power spectral density mask is used by the CDMA system and that the GLONASS operates in an antipodal manner.

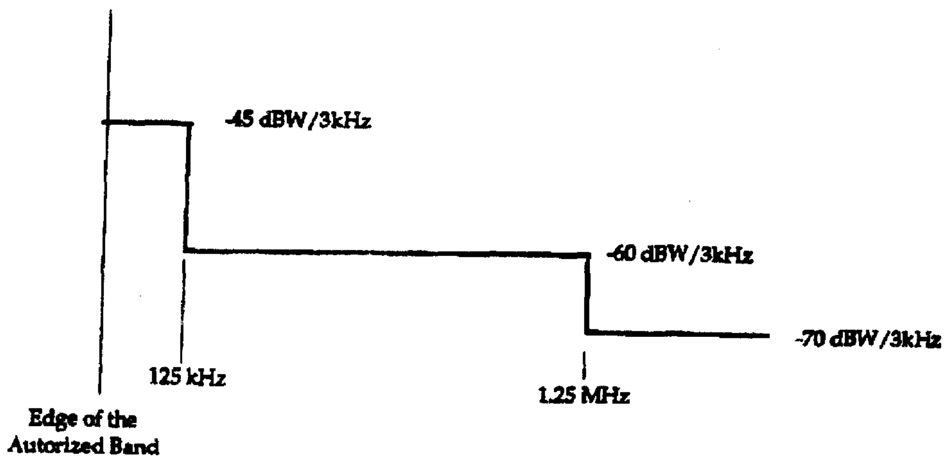

Figure 2 Recommended Spectral Mask

Table I Calculated Mobile CDMA Subscriber Unit to Aircraft GLONASS Receiver

PARAMETER	UNITS	A/C Overhead	A/C Turning	NOTE
Freq Offset from Band Edge	KHz	1.25	1.25	1
Subscriber Transmit Power	dBW	4.0	4.0	2
Subscriber Power Spectral Density	dBW/3KHz	-62.6	-62.6	3
PSD Bandwidth Factor for 3 KHz	dB	-34.8	-34.8	
Subscriber Power Spectral Density	dBW/Hz	-97.4	-97.4	
Subscriber Antenna Gain	dB	0.0	0.0	4
Subscriber Duty Cycle	dB	0.0	0.0	5
GLONASS Bandwidth	dB	56.9	56.9	6
Subscriber Power in GLONASS BW	dBW	-42.4	-42.4	
Receiver Out-of-Band Attenuation	dB	-46.4	-46.4	7
Subscriber Range to GLONASS Ant	m	100.0	2000.0	
Path Loss	dB	-76.6	-102.6	8
Estimated Shielding Loss (aircraft)	dB	-30.0	0.0	9
Total Losses	dB	-106.6	-102.6	
Subscriber Power at GLONASS Ant	dBW	-149.0	-145.0	
Allowed In-band Interference	dBW	-140.0	-140.0	10
Theoritical In-band Margin	dB	9.0	5.0	

Notes:
1. Separation from GLONASS channel center to lower edge of MSS allocarted band at 1610.0 MHz. Corresponds to GLONASS channel 12. (see figure 2)
2. Subscriber unit uplink earth-to-space transmission power.
3. The recommended out-of-band PSD limit is -60 dBW/3KHz below 1.25 MHz and -70 dBW/3KHz above 1.25 MHz. and average value of -62.6 dBW/3KHz incorporated.
4. Zenith gain = 4.0 dB, horizon gain = 0.0 dB.
5. CDMA transmit duty cycle = 100% (worst case) due to pilot carrier
6. Receiver 490 KHz bandwidth (3 db points) of GLONASS narrowband IF filter before spread-spectrum correlator
7. As specified in RTCA paper no. 518-91/SC159-317
8. Path loss = $10 \log_{10} (\lambda/4\pi R)^2$
9. Estimate of lower hemisphere A/C shadowing and antenna sidelobe loss (30 dB)
10. RTCA paper no. 518-91/SC159-317 and ARINC-743A-1 specification; allowed in-band interference for the "Alternate Configuration"

Table 2 shows the results of laboratory tests using a properly designed GLONASS receiver (3S Model R-100 identifed). This test data confirms that a properly designed GLONASS receiver will meet the criteria defined in Table I.

To achieve the desired level of performance, a GLONASS receiver must incorporate an effective IF bandwidth of 490 KHz and an out-of-band attenuation of 44 dB at 1.0 MHz and 55 dB at 1.5 MHz from the GLONASS channel center. The CDMA transmitter must conform to the following recommended out-of-band power spectral density limits below 1610.0 MHz:

Frequency	PDS Limit
1610.0 to 1609.875 MHz	-45 dBW/3KHz
1609.875 to 1608.75 MHz	-60 dBW/3KHz
below 1608.75 MHz	-70 dBW/3KHz

The link budgets of Tables I and II both show that the GLONASS receiver will continue to operate in the presence of the specified MSS emissions. Although the measured interference margin for GLONASS channel 12 is quite small, the margin improves to better than 7 dB at channels 11 and lower.

Table II Measured Mobile CDMA Subscriber Unit to Aircraft GLONASS Receiver

PARAMETER	UNITS	A/C Overhead	A/C Turning	NOTE
R-100 Receiver In-band Test	dBW	-167.0	-167.0	1
Allowed In-band Interference/signal	dB	26.0	26.0	2
Allowed In-band Interference	dBW	-141.0	-141.0	3
R-100 In-band Interference Margin	dB	0.0	0.0	

Notes:
1. Power of simulated GLONASS signal acquired and tracked during testing of the 3S Navigation R-100 receiver configured to the ARINC-743A "Alternate Configuration"
2. Maximum in-band interference signal at which the R-100 receiver was observed to acquire and track a GLONASS signal of -167 dBW
3. Maximum in-band interference level at which the R-100 receiver was observed to acquire and track the -167 dBW GLONASS signal

2.2.1 Other Interference Mitigation Considerations

2.2.1.1 Interference Channel Combinations

The probability of interference on a "channels in use" basis must be considered for the GLONASS receiver as well as an MSS transmitter. That is, a GLONASS receiver need only receive 4 channels of the 12 channels available to perform its function (3 with barometric assist).

For purposes of illustration, assume that GLONASS is operating in an antipodal mode with 12 channels distributed over the band 1602.15 - 1609.26 MHz. Of these channels, a simple GLONASS receiver normally selects the best 4 of 6 satellite channels for position computation. A quality GLONASS receiver would select the best 4 of 8 channels. If one channel were to become degraded, the receiver reselects from the remaining channels. It is necessary to degrade all but 3 of the usable GLONASS receiver channels before any significant impact will be inflicted on a GLONASS position solution.

Assuming that a CDMA MSS system is operating on the lowest channel in the band 1610.0 - 1621.35 MHz, and that out-of-band power from the CDMA channel overlaps the top four GLONASS channels, for a random distribution of both the GLONASS and MSS channels:

a. The probability of the highest four frequency GLONASS channels being simultaneously active is 1 in 495, or 0.002
b. The probability of the lowest frequency CDMA channel impacting one of the active GLONASS channels is 1 in 3960, or 0.00025.

While this example is purely hypothetical, interference with a single GLONASS channel is not sufficient to cause harmful interference. The probability of out-of-band MSS radiation adversely impacting three or more GLONASS channels is indeed remote.

2.2.1.2 Spectral Power Overlap

The channel out-of-band structure of the subscriber transmitter and the GLONASS receiver must be analyzed for each individual MSS system to derive spectral overlap power. The overlap power is spread over the channel bandwidth of the GLONASS receiver and integrated for 20 ms before being declared a 1 or a 0 by the receiver message processor.

Both the magnitude of the overlap power and the time duration of the interference event must be considered in determining whether a GLONASS channel will be adversely affected.

2.2.1.3 Duty Cycle Considerations

The probability of MSS interference will be further reduced by duty cycle considerations. Many MSS systems will operate in a burst mode, where average power is more important than peak power. MSS systems can range from a 10% duty cycle to as much as 100% (for short periods).

Another duty cycle factor to consider is that voice communications are not continuous. Many MSS systems reduce transmitter power during breaks in conversations - to conserve battery power. A typical figure for voice duty cycle is 60% on time, 40% off time.

In general, MSS systems will reduce transmitter power to the minimum level required to maintain their specified bit error rate. Depending upon the MSS system, transmitter power can be reduced 10 to 15 dB below peak when unobstructed viewing conditions exist. Various statistical estimates have shown that, on the average, only 33% of a subscriber community requires full power to achieve the desired communications bit error rate. The remaining 66% of the community will operate at substantially reduced values of transmitter power.

Day-night conditions impact the number of subscribers serviced. Global estimates have shown that the number of night hour subscribers is typically 50% of the day load.

Each of the preceding factors is a valid parameter that must be considered in determining the affect of MSS duty cycle on interference.

2.3 Motorola GLONASS Compatibility Study Program

The criteria for evaluating MSS interference on a GLONASS radionavigation receiver must take into account: (1) the physical geometry - where interference can take place, (2) the effective strength of the interfering signal, (3) the frequency of the interfering event, and (4) the ultimate aircraft system use of the GLONASS position measurement. In addition certain of the conditions for interference assessment are probabilistic in nature. A meaningful analysis must treat all of the conditions noted in this paper.

2.3.1 Motorola Iridium-GLONASS Compatibility Studies

Motorola has been in the process of performing a detailed analysis of Iridium compatibility with GLONASS. Phase I of the study was devoted to modeling an idealized Iridium system and GLONASS receiver in the scenarios described by paragraph 2.1.2 of this paper. This phase was completed in July 1993 with the result that a small guard band (approximately 0.5 MHz) could provide the needed protection between the Iridium system and GLONASS operation.

Phase II of the study involved hardware testing of an Iridium subscriber unit and a representative CDMA subscriber unit operating in conjunction with a GLONASS receiver. This phase confirmed the basic Phase I Iridium-GLONASS results but suggested a wider guard band (approximately 1.5 MHz between band edges) be allowed between the lowest frequency Iridium channel and the highest frequency GLONASS channel. With the relocation of GLONASS to frequencies lower than 1610.0 MHz there will be no Iridium-GLONASS interference.

Phase II also confirmed that a GLONASS aviation receiver can operate in the presence of out-of-band emissions from a CDMA type subscriber unit. The primary effect of a CDMA transmission is to raise the noise floor of the GLONASS receiver. The actual need for a guard band between the CDMA system and GLONASS is subject to further analysis. Depending upon (a) aircraft system vulnerability, (b) interference statistics, (c) CDMA output filtering characteristics (out-of-band power control), and (d) the manner in which a GLONASS receiver processes CDMA interference, a guard band may not be needed.

2.3.2 GLONASS Receiver Design Considerations

The GLONASS receiver must be properly designed to prevent interfering signals from entering its AGC circuitry. An appropriate GLONASS bandpass front end filter and a narrowband IF filter must be incorporated in the design of the receiver to reduce susceptibility to interference. This requirement is not unusual; military and aviation receiver systems commonly employ such filters to prevent extraneous radiation from degrading receiver performance.

3. CONCLUSIONS

The analysis of interference between an MSS subscriber unit and an aircraft GLONASS receiver requires that consideration be given to all of the parameters that affect the vulnerability of the GLONASS system. The analysis must include:

a. A definition of interference vulnerability for the particular aircraft GLONASS system;
b. An estimate of effective spectral power flux density based on:

  - Spectral power flux density present at a GLONASS antenna
  - Allowance for MSS duty cycle, power control, and voice activity factor

c. An estimate of the likelihood of an interference event. As a minimum this estimate should include:

  - Propagation path geometry and time duration of exposure
  - Frequency of aircraft arrivals/departures
  - Probability of an undesirable MSS-GLONASS channel set selection
  - Probability of interfering with all but three GLONASS channels
  - Probability allowance for voice factor
  - Probability allowance for MSS power control
  - Probability allowance for day-night subscriber population
  - Probability of two or more simultaneous MSS transmissions

A final determination of harmful interference is comprised of items b and c equated against system vulnerability as defined in statement a. Preliminary calculations by Motorola suggest that MSS subscriber interference with an aircraft GLONASS receiver is highly unlikely, so long as the receiver is properly designed and the MSS subscriber unit includes sufficient bandpass filtering in its output to attenuate unwanted out-of-band radiation.

4. REFERENCES

a. "GPS/GLONASS Sensor," ARINC Characteristic 743A, March 16, 1992

b. "General Considerations Relative to Harmful Interference from the Viewpoint of the Aeronautical Mobile Services and the Aeronautical Radionavigation Service," CCIR Report 927-2, 1990

c. "Feasibility of Frequency Sharing Between the GPS and Other Services," CCIR Report 766-2, 1990

d. "A Review of Interference and Jamming Resistance of SPS GPS Receivers in Aviation," Owen, J.I.R., Defence Research Agency, Farnborough, May 21, 1992

e. "Global Satellite Navigation System GLONASS," 2nd Wording, ICD-GLONASS, Institute of Space Device Engineering, Moscow, Russia

f. "Navstar GPS Space Segment/Navigation User Interfaces (Public Release Version)," ICD-GPS-200, IRN-200B-PR-001, July 1,1992

g. "Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS), "RTCA/DO-208, July 1991

h. International Telecommunications Radio Regulations, RR 953, 1990

i. "Protection for Radionavigation Services," IWG2-27, L. Chesto, Feb 4, 1993

j. "Technical Report on MSS/RDSS Sharing with Aeronautical Radio-navigation," IWG2-36, L. Chesto, Feb 16, 1993

k. "GPS/GLONASS Cover and Outage Times," IWG2-50, L. Chesto, Feb 25, 1993

l. "IRIDIUM GLONASS Sharing, IWG2-58, J. Knudsen, Mar 5, 1993.

m "Global Satellite Navigation System GLONASS - Interface Control Document (Second Wording)," RTCA paper no. 518-91/SC159-317

n. "RTCA Task Force Report on the Global Navigation Satellite System (GNSS) Transition and Implementation Study," RTCA Inc., Sept. 1992

o. "Technical Appendix to Comments of Loral/Qualcom Partnership, L.P., Volume I of II, " CC Docket No. 92-166, May 5, 1994

p. "Comments of Motorola Satellite Communications, Inc.," CC Document No 92-166, May 5, 1994

<u>ENGINEERING CERTIFICATE</u>

I hereby certify that I am the technically qualified person responsible for preparation of the engineering information contained in these Reply Comments and the Technical Appendix hereto, that I am familiar with Part 25 of the Commission's Rules, that I have either prepared or reviewed the engineering information submitted in these Reply Comments and Technical Appendix, and that it is complete and accurate to the best of my knowledge and belief.

John T. Knudsen

John T. Knudsen

Title: <u>Director of Spectrum</u>
<u>Motorola Satellite Communications</u>

Date: June 13, 1994

Satellite Navigation

Hinson formally declares GPS IOC ready for civil aviation use
- becomes integral part of NAS

FAA Administrator David Hinson announced that the GPS IOC satellite navigation system is now operational and is henceforth an integrated part of the U.S. air traffic control system. Calling this announcement, "arguably the most significant advance in the history of aviation navigation," Hinson told assembled reporters and FAA management staff "this is a day you will all remember." This announcement completes the essential two-step process of moving GPS from an interesting military R&D project to a key ingredient in the U.S. national air space system (NAS). The first step occurred in December 1993, when DoD notified DoT that the GPS IOC constellation had been achieved.

Hinson's declaration means that the GPS civil signal (SPS) now meets the performance characteristics defined in the 1992 Federal Radionavigation Plan (FRP), and is approved for civil aviation use in the NAS. With the certification of the first GPS receivers (from Garmin) to meet full TSO C129/A1, GPS is now the first navigation system to be approved for use as a stand-alone navigation aid for all phases of flight, through non-precision approach.

Blanchard calls for European satellite "contribution"
- to augment GPS constellation

Walter Blanchard, President of the Royal Institute of Navigation (RIN) in London, feels Europeans have something to offer the world satnav community. "Europe's main and major contribution and specialization is that of differential systems - required for improving GPS accuracy and increasing its integrity ... We hope, too, on the European front that before long there will be a solid contribution in the form of more satellites in the sky. Together with GPS they will provide a navigation system usable by everyone." The RIN is hosting the annual DSNS meeting in London in April. (See CNS Calendar)

Wilcox/NASA DGPS flight test results
- claim "CAT 3 accuracy by wide margins"

Wilcox Electric has released data analyzed from its DGPS autoland flight tests conducted with NASA, and claims that CAT 3 accuracies, using RNP tunnel concept standards, were achieved by wide margins (3-to-1 laterally, 35% better than RNP vertically). These flight tests were "the first time DGPS autolands have been achieved without the use of special equipment or processing techniques, such as tightly coupled IRUs or carrier phase tracking," per Wilcox. Basic GPS code-tracking was used to determine the aircraft position. 31 hands-off landings were completed last fall, using a Wilcox DGPS ground station and a NASA B737 aircraft. Wilcox acknowledges that integrity requirements will be more difficult to achieve than accuracy.

SATNAV Master Plan nears publication
- copies available soon from FAA

The annual update of the Satellite Navigation Five Year Master Plan is expected to be released by FAA within the next few weeks. FAA calls it "a comprehensive document covering all aspects of the FAA's research and development of satellite navigation concepts," for the period 1994-1999. To get on the document distribution list, contact the FAA Satellite Program Office, ARD-70, at 202-267-7219.

GPS for CAT 3 landings and taxiing
- addressing the 0/0 airport problem

Citing the millimeter navigation accuracies demonstrated recently by Stanford University, FAA Administrator Hinson said "there is no reason at all we can't have CAT 3a/b landings and taxiing at the airport in zero-zero conditions; GPS fixes that problem. From a technical standpoint, I believe that GPS will be the only system we'll need to safely and efficiently manage our airspace. From the standpoint of economics and public policy, I believe it is the only system that makes sense." Regarding the role of other navaids, Hinson says "eventually, navigation satellites and cockpit receivers will very likely replace the vast and costly array of radio and radar which we now rely on. GPS is fundamentally all you need to operate." Asked about what kind of savings GPS will provide the airlines, Hinson estimated "about $5-10 billion in fuel and time."

TOTAL P.03

U.S. Department
of Transportation
Federal Aviation
Administration

800 Independence Ave., SW.
Washington, DC 20591

June 8, 1994

TO: PROSPECTIVE OFFERORS

SUBJECT: Request for Proposal(RFP) Number DTFA01-94-R-21474 - Wide Area Augmentation System (WAAS)

You are invited to submit a proposal to the Federal Aviation Administration (FAA) for the development of the WAAS. The WAAS is a safety critical system consisting of the equipment and software which augments the Department of Defense provided Global Positioning System Standard Positioning Service. The objectives of the WAAS are to provide for improved integrity, accuracy, and availability to satisfy the Required Navigation Performance (RNP) for sole-means operation for oceanic en route through precision approach.

The FAA is embarking on an aggressive schedule to acquire and implement the WAAS. The initial WAAS, anticipated to consist of 24 ground reference stations plus terrestrial and satellite communications systems, is scheduled for delivery by mid-1997.

The Government reserves the right to award a contract based on initial proposals, without discussions or negotiations. Therefore, it is critical that proposals are fully responsive. In addition, we strongly recommend that offerors submit proposals that accurately substantiate what costs would most likely be incurred utilizing your proposed technical and management approach.

Pursuant to FAR 9.5, "Organizational Conflicts of Interest," offerors may request an initial Organizational Conflict of Interest determination prior to submitting proposals.

The WAAS RFP has been electronically replicated in Farallon's Replica for Windows version 1.01 and is being provided on four (4) 3.5" diskettes. The instructions for installing the RFP on your hard disk are provided in Attachment A. Standard Form (SF) 33, "Solicitation, Offer and Award", and other forms not available on computer medium are provided in Attachments B through F.

To be considered responsive, your proposal must be marked valid for at least 365 days from the date of submittal. Volume I - Technical Proposal must be received by the FAA no later than 2:00 p.m., e.s.t., September 7, 1994. Volume II - IV must received no later than 2:00 p.m., e.s.t., September 21, 1994. All proposals should be forwarded to the following address:

Federal Aviation Administration
800 Independence Avenue, S.W.
Washington, D.C. 20591
Attention: Sarah F. Scott, ASU-340
or Rita McNair, ASU-340

In addition, a copy of your proposal and a copy of the RFP should be submitted to your cognizant Defense Contract Audit Agency, see Section L for instructions.

The Contracting Officer is the single point of contact for any and all communication between the Government and industry.

Sincerely,

Sarah F. Scott
Contracting Officer

Attachments

1.0 Scope

This statement of work (SOW) defines the requirements for the program management, engineering management, production, test and evaluation, turnkey installation, and technical support of the Wide Area Augmentation System (WAAS) being procured by the Federal Aviation Administration (FAA).

The Contractor shall provide a WAAS which shall enhance the availability of the Global Positioning System (GPS) through the broadcast of GPS-like ranging signals, provide integrity broadcasts to permit aviation users to determine when the GPS should not be used for each phase of flight, and provide differential correction messages with sufficient accuracy to support precision approaches. The WAAS shall meet the specific functional and performance requirements of the WAAS Specification, FAA-E-2892 and shall be provided to the Government in accordance with the requirements cited in this Statement of Work (SOW).

The Contractor shall deploy a WAAS that shall provide data to users that augment the Department of Defense (DoD)-provided GPS so that positioning and navigation performance meets FAA navigation requirements for oceanic and domestic enroute, terminal, nonprecision approach, and precision approach phases of flight. The Contractor shall utilize the NAS Interfacility Communications System (NICS) to provide ground-ground communications between the various Contractor-provided Hardware Configurations Items.

The Contractor shall provide, as a minimum, the following for the WAAS:

a. System analysis and design using software, firmware, communications media, and non-developmental item (NDI) hardware (referred to as equipment hereafter);
b. All ground-based components and equipment including Wide-area Master Stations (WMS), Wide-area Reference Stations (WRS), Ground Earth Stations (GES), and communications interface equipment.
c. Geostationary Earth Orbit (GEO) Satellite Communications services,
d. Software to perform the functions described in the WAAS Specification, FAA-E-2892.
e. Operation, monitoring, management, logistics support (including interim maintenance), installation, and training.
f. Related documentation.

CERTIFICATE OF SERVICE

I, Pantelis Michalopoulos, hereby certify that copies of the foregoing Reply Comments of Motorola Satellite Communications, Inc. on Notice of Proposed Rulemaking were served by first-class mail, postage prepaid, this 20th day of May, 1994 on the following persons:

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